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(71) Applicant (for all designated States except US): BRITISH TELECOMMUNICATIONS PUBLIC LIMITED COMPANY [GB/GB]; 81 Newgate Street, London EC1A 7AJ (GB).

(72) Inventor; and
(75) Inventor/Applicant (for US only): ELLIS, Andrew [GB/GB]; 18 Bowland Drive, Ipswich, Suffolk IP5 7RE (GB).

(74) Agent: GILL JENNINGS & EVERY; Broadgate House, 7 Eldon Street, London EC2M 7LH (GB).

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(54) Title: CHROMATIC DISPERSION COMPENSATING NODE
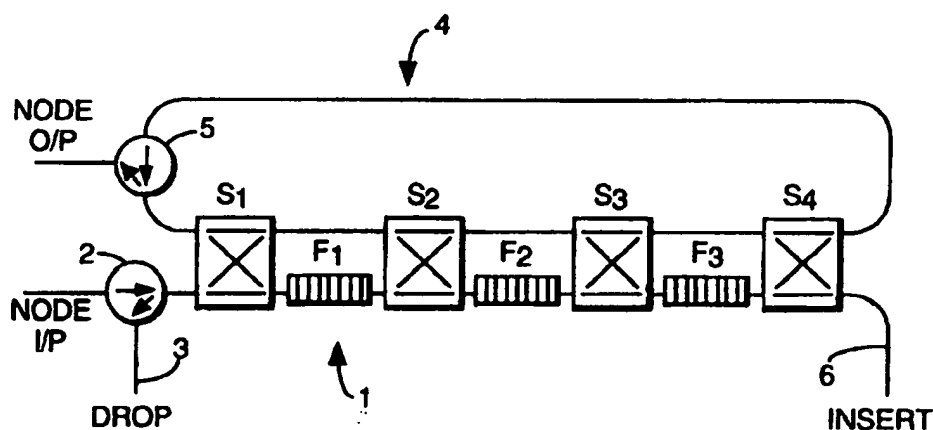
(57) Abstract

In the present invention, wavelength division multiplexed transmission line functions of chromatic dispersion compensation and channel drop are performed by a node having a concatenated series of wavelength selective dispersion compensating elements (F₁-F₃) and switches (S₁-S₄). The switches (S₁-S₄) are arranged to select or bypass each wavelength selective dispersion compensating element (F₁-F₃). If a wavelength selective dispersion compensating element (F₁-F₃) is appropriately selected, the corresponding channel ($g(1)_1$-$g(1)_3$) is dispersion compensated and reflected to a drop port (3). Any remaining channels are circulated by the switches (S₁-S₄) to the remaining dispersion compensating elements (F₁-F₃) where they are dispersion compensated and reflected to an optical output (5). In the preferred examples, the node includes an insert port (6) to allow multiplexing of additional channels. This allows the node to perform both drop and insert functions in addition to dispersion compensation and so forms a dispersion compensating drop and insert node.

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CHROMATIC DISPERSION COMPENSATING NODE

Technical Field

The present invention relates to a structure for
dispersion compensating a wavelength division multiplexed
(WDM) signal in an optical network.

Background Art

The most efficient use of the available optical
communication bandwidth can be achieved by multiplexing a
number of different optical communication channels over a
single optical fibre.   One of the most promising
multiplexing schemes is WDM in which channels have
different wavelengths.   In addition to increasing the
capacity on any individual point to point communication
link, it is known that such optical multiplexing offers
many potential advantages in the provision of coarse
traffic routing, simplified switching architectures and
advanced restoration facilities. In high speed WDM optical
networks using embedded standard fibre, chromatic
dispersion is a key limiting factor.   A number of
techniques for compensating chromatic dispersion are known.
In one conventional technique, fibre gratings are used to
perform dispersion compensation. Other techniques include
the use of dispersion compensating fibre or dispersion
tolerant transmission formats.

Optical multiplexers/demultiplexers are provided in
WDM networks to drop or insert one or more wavelengths at
a node. Again, it is known that fibre gratings may be used
to perform this drop and insert function.

At present, dispersion compensation and drop and
insert functions in WDM networks are carried out
separately. Furthermore, any flexibility in routing is
provided by a further functional block including electro-
optic switches or electro-mechanical optical switches.
Accordingly, at present at least three functional blocks
are required in a given system.

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The document US-A-5,048,909 discloses a chromatic dispersion compensating device having a chirped fibre grating for selectively dropping and dispersion compensating one channel within a WDM optical signal.

Disclosure of Invention

According to a first aspect of the present invention, a chromatic dispersion compensating node for connection to a transmission medium carrying a wavelength division multiplexed optical signal having N channels corresponding to N different wavelengths, comprises:

an optical input;

an optical output;

at least one drop port; and,

switching means for selectively coupling each of a series of N wavelength selective dispersion compensating elements, each of which is tuned to a respective one of the N wavelengths, to one of the drop port and the output port, the node thereby selectively dropping one or more of the N channels and dispersion compensating all of the N channels.

According to a second aspect of the present invention, an optical communication network comprises a number of chromatic dispersion compensating nodes in accordance with the first aspect of the present invention.

In the present invention, wavelength division multiplexed transmission functions of chromatic dispersion compensation and channel drop are performed by a node having a number of wavelength selective dispersion compensating elements and switching means. The switching means is arranged to select or bypass each wavelength selective dispersion compensating element. If a wavelength selective dispersion compensating element is selected, the corresponding channel is dispersion compensated and reflected to one of a number of drop ports. Any remaining channels are circulated by the switching means to the remaining dispersion compensating elements where they are

dispersion compensated and reflected to the optical output.

Preferably, the node includes an insert port to allow
multiplexing of additional channels. This allows the node
5 to perform both drop and insert functions in addition to
dispersion compensation and so forms a dispersion
compensating drop and insert node.

Preferably, the wavelength selective compensating
elements are chirped fibre gratings. These fibre gratings
10 are reflective and may be tuned to a desired wavelength
corresponding to one of the N channels. As each of the
chirped fibre gratings is independent, characteristics of
the fibre gratings can be tailored to suit particular
transmission formats of that channel. Thus each channel
15 may offer services at different bit rates and with
different modulation schemes, examples of which include
standard NRZ binary formats and RZ optically time division
multiplexed formats. Furthermore, each grating may be
individually tuned in dispersion to allow for variations in
20 transmission line dispersion with wavelength.

Preferably, the optical input, optical output and drop
ports are optical circulators. Power splitters and optical
isolators are alternatives.

In a first preferred example, the switching means
25 comprises a series of discrete 2x2 non-blocking optical
switches. In second and third preferred examples, a single
MxN multi-point switch is used.

Preferably, the switching state of each of the
switches is controlled by a network node controller. The
30 network node controller determines the switch configuration
to perform the routing of the received channels. The
network node controller may be local or remote.

Where necessary, additional optical amplifiers may be
used to boost signal power and thereby overcome any loss
35 problems associated with the switching elements.

According to a third aspect of the present invention,
a cross-point switch for an optical network comprises two

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chromatic dispersion compensating nodes according to the first aspect of the present invention, in which a drop port of each node is connected to the other node.

The drop ports of the two cross-connected dispersion
5   compensating nodes of the first aspect of the present invention are used to perform an insert function to route a channel from one transmission line to another. Preferably, the drop port of one node is connected to the insert port of the other node.

10 In one embodiment, corresponding switches in the two connected nodes are arranged to be set to the same switch state to ensure that the same wavelengths are exchanged. In this configuration, all channels are dispersion compensated only once.

15 In another embodiment, the switch states of corresponding switches are independent of each other and an optical circulator is provided in each of the drop ports connecting the two nodes to provide a local drop facility.

In the present application the term "corresponding
20 switches" are those switching elements within two dispersion compensating nodes which have the effect of coupling a wavelength selective dispersion-compensating element tuned to a particular channel to the optical output or a drop port so that the two nodes mirror each other's
25 behaviour.

According to a fourth aspect of the present invention, an optical communication network comprises a number of cross-point switches in accordance with the third aspect of the present invention.

30 According to a fifth aspect of the present invention, an optical communication network comprises a combination of one or more chromatic dispersion compensating nodes according to the first aspect of the present invention and one or more cross-point switches according to the third
35 aspect of the present invention.

5

Brief Description of Drawings

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

5   Figure 1 shows a block diagram of a first example of a dispersion compensating node for a three channel optical fibre transmission line;

Figure 2 illustrates a drop and insert operation of the dispersion compensating node of Figure 1;

10   Figure 3 shows a block diagram of a first example of a cross-point switch incorporating two cross-connected dispersion compensating nodes;

Figure 4 shows a block diagram of a second example of a cross-point switch incorporating two cross-connected

15   dispersion compensating nodes;

Figure 5 shows a block diagram of a network element incorporating a dispersion compensating node;

Figure 6 shows a block diagram of a second example of a dispersion compensating node;

20   Figures 7 to 9 illustrate a number of operating states of the dispersion compensating node of Figure 6;

Figure 10 shows a block diagram of a third example of a dispersion compensating node; and,

Figure 11 shows an example of an operating state of

25   the dispersion compensating node of Figure 10.

Detailed Description

Figure 1 shows a schematic diagram of the present invention for a three channel optical transmission line.

30   The dispersion compensation node comprises a first optical fibre 1 having an optical circulator input 2 which provides a drop port 3, and a second optical fibre 4 having an optical circulator output 5 which provides a return path to the first optical fibre 1. The first optical fibre 1

35   includes a concatenated series of 2 x 2 non-blocking switches S_1 - S_4 and chirped fibre gratings F_1 - F_3, each of which is tuned to a respective one of the three possible

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wavelengths λ_1 - λ_3. The optical circulator input 2 serves
as a drop port 3 and the free end of the optical fibre of
the first optical fibre 1 is utilised as an insert port 6.
An example of a suitable switch is the JDS Fitel SR 22
5   switch. Suitable fibre gratings are described by Raman
Kashap et al in a paper entitled "A novel method of
producing all fibre photo-induced chirped gratings",
Electronic Letters, 1994. These gratings, unlike
conventional fibre gratings, have a distributed period.
10   Finally, an example of an optical circulator is the JDS
Fitel CR 1500 optical circulator.

Channels to be reflected are selected by the
appropriate switch to the left of the respective grating.
The final switch S_4 ensures that any remaining channels are
15   circulated around the second optical fibre 4 and optical
circulator 5 to the input of the chain of fibre gratings.
The switch positions then ensure that all of the remaining
wavelengths are reflected back to the optical circulator
output 5 by the previously unused fibre gratings. In this
20   manner, all three channels of the transmission line are
reflected from a respective fibre grating and are thus
dispersion compensated, and are directed either to the
optical output 5 or drop port 3.

If a signal is input to the insert port 6, any
25   channels corresponding to those previously dropped from the
drop port 3 are directed to the output circulator 5, thus
performing an insert function, whilst any channels not
previously dropped are reflected straight back to the
insert port 6 from the appropriate fibre grating.
30   An example of the operation of the dispersion
compensation node of Figure 1 is shown in Figure 2.

A three channel WDM signal in an optical transmission
line is received at the first input circulator 2. Channel
1 (λ_1) is reflected from the first grating F_1 in a first
35   optical path whilst channels 2 (λ_2) and 3 (λ_3) pass through
unmodified. Channel 1 is thus dispersion compensated and
directed to the drop port 3 by the optical circulator input

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2. The switch S_2 is set so that channels 2 and 3 bypass their fibre grating F_2 and F_3, respectively, circulated around the second optical fibre 4, and are subsequently reflected back to the optical circulator output 5 via switch S_2 by their respective gratings in a second optical path. Accordingly, channels 2 and 3 are dispersion compensated and routed to the node output 5.

A WDM signal input to the insert port 6 can replace channels which have previously been dropped. For example, with the switch states shown, a signal introduced at the insert port 6 corresponding to channel 1 passes through gratings F_2 and F_3 undisturbed and emerges at the optical circulator output 5. However, channels 2 and 3 will be reflected from their respective gratings and will return to the insert port 6.

Additional channels may be added simply by inserting an additional 2 x 2 switch and an appropriate chirped fibre grating.

Figure 3 shows an extension of the dispersion compensation node of Figures 1 and 2 to provide a 2 x 2 cross-point switch. The cross-point switch comprises two identical nodes with the drop port fibres 7 and 8 of each dispersion compensation node cross-connected to the first optical fibre 1 of the other i.e. the drop ports 3 and insert ports 6 of the two nodes are cross-connected. In this example, corresponding switches of the device, i.e those with the same switch numbers, are set to the same state to ensure that the same channel is exchanged by the two halves of the cross connect. Corresponding chirped fibre gratings are tuned to reflect the same channel (λ), but the degree of dispersion compensation provided by each grating may be tuned to take account of the individual transmission line dispersion characteristics.

In the example in Figure 3, no spare connection exists for local drop and insert. However, by allowing corresponding switches to adopt different switch states and providing optical circulators 9 and 10 in the connecting

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optical fibres 7 and 8, it is possible to implement a local drop function. Figure 4 illustrates an example where optical circulators 9 and 10 are provided to achieve this. In this example, channel 3 on the first compensating node

5   is dropped.   The drop is set by arranging the first dispersion compensating node to drop channel 1 and 3 and the second dispersion compensating node to drop channel 1. As channel 1 on the first dispersion compensating node is dropped, the insert port 6 on this node will accept channel

10   1 from the drop port 3 of the second dispersion compensating node.   However, as channel 3 has not been dropped from the second dispersion compensating node, when this channel is offered to the insert port 6 of the second dispersion compensating node it is reflected to the local

15   drop port 11 of the optical circulator 9 as shown in the Figure.   In this embodiment, it is important that the reflectivity of the chirped fibre gratings is sufficient to ensure that the dropped channels do not degrade the performance of other channels of the same wavelength

20   through cross-talk.

        The truth tables dictating the switch state for a 2 channel and a 3 channel dispersion compensating node which implements both drop and insert functions are shown below in Table 1 and Table 2, respectively, where the wavelength

25   routings are represented logically as:
        "0" = transmitted
        "1" = reflected (dropped)
        and the switch settings are represented logically as:
        "0" = bar

30   "1" = cross

<div align="center">TABLE 1</div>

Wavelength 1 (λ_1)	2 (λ_2)	Switch S_1	S_2	S_3
0	0	1	0	0
0	1	1	1	1
1	0	0	1	0
1	1	0	0	1

35

TABLE 2

Wavelength			Switch			
1 (λ_1)	2 (λ_2)	3 (λ_3)	S_1	S_2	S_3	S_4
0	0	0	1	0	0	0
0	0	1	1	0	1	1
0	1	0	1	1	1	0
0	1	1	1	1	0	1
1	0	0	0	1	0	0
1	0	1	0	1	1	1
1	1	0	0	0	1	0
1	1	1	0	0	0	1

From the above tables, it is possible to deduce the following:

S_1 = NOT (λ_1) = XOR (λ_1,1)

S_2 = XOR (λ_1, λ_2)

S_3 = XOR (λ_2, λ_3)

S_4 = λ_3 = XOR (λ_3, 0)

and therefore for switch n of N wavelengths (channels):

$$S_n = \lambda_{n-1} \text{ XOR } \lambda_n$$
$$\lambda_o = 1 \text{ , } \lambda_{N+1} = 0$$

This allows the switch configuration to be determined for an arbitrary number of wavelengths in the drop and insert configuration.

Figure 5 shows a block diagram of a system for implementing dispersion compensation and drop and insert functions in a two channel transmission line. The system comprises a network node controller 12, an XOR logic array 13, and a dispersion compensation node 14 having an optical input 15, an optical output 16, a drop port 17 and an insert port 18. The network management controller 12 controls the state of the switches S_1 - S_3 within the dispersion compensating node 14 through the XOR logic array 13. Setting an input to channel 1 (λ_1) or channel 2 (λ_2) to logic "1" in the logic array means that the channel is

to be dropped to the drop port 17. Channel 0 (λ_0) and channel 3 (λ_3) of the XOR logic array 13 are held at logic "1" and "0", respectively, to implement the required switch settings.

Figure 6 shows a second example of the present invention where the dispersion compensating node is formed from a single multipoint switch 19 and a number of chirped fibre gratings 20. An example of a suitable switch is that sold under the trade name JDS Fitel SG Series MxN Single Mode Matrix Switch. As shown, the outputs of each fibre grating 20 are connected to the input of the succeeding switching element within the multipoint switch 19. The inputs of each of the switching elements are selectively connectable to any of the outputs of the switching elements to perform the required dispersion compensation and any drop and insert function.

An optical circulator 21 is connected to the input of the first switching element and so provides an optical input 22 and a drop port 23. A further optical circulator 24 forms an optical output 25. The output of the sixth switching element provides an insert port 26.

Figure 7 shows the switch states for an operation which performs dispersion compensation for each of four channels received at the optical input 22 and drops channels 2 and 4.

The switch states are selected so that the chirped fibre gratings F_2 and F_4 are within a first optical path. Channels 2 and 4 are dispersion compensated in this first optical path and reflected to the drop port 23. The remaining channels pass through these fibre gratings undisturbed and are circulated to a second optical path which includes chirped fibre gratings F_1 and F_3 where channels 1 and 3, respectively, are dispersion compensated and reflected to the optical output 25. As in the first example of the present invention, if required, channels 2 and 4 can be introduced at the insert port 26 from a second transmission line to perform a multiplexing operation.

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Again, any channels introduced at the insert port 26 which have not been previously dropped will be reflected by their corresponding chirped fibre grating 20 and returned to the insert port 26.

Figure 8 illustrates the dispersion compensation of all four channels received at the optical input 22 and a drop operation with respect to channel 3.

Figure 9 shows the dispersion compensation of all four channels received at the optical input 22 and transmission of all four channels to the optical output port 25.

Figure 10 shows a third example of the present invention which is an extension of the multipoint switch architecture of the second example described with reference to Figures 6 to 10 of the accompanying drawings. In this third example, in addition to the drop port 23 and output port 25, second and third optical circulators 27 and 28, respectively, are provided as drop ports 29 and 30, respectively. This allows the dispersion compensating node to drop channels to more than one other transmission line for routing across an optical network.

Figure 11 shows the switch states for an operation which performs dispersion compensation for each of four channels received at the optical input 22 and drops channel 2 (λ_2) from drop port 23, drops channel 4 (λ_4) from drop port 29, and transmits channel 1 (λ_1) and channel 3 (λ_3) from the optical output 25. Again, insert port 26 is arranged to multiplex channels from other transmission lines (not shown). In this example, drop port 30 is unused.

As shown, the switch states in the dispersion compensating node of Figure 11 are selected so that the chirped fibre grating F_2 is in a first optical path, chirped fibre grating F_4 is in a second optical path, and chirped fibre gratings F_1 and F_3 are in a third optical path. Channels tuned to any of the one or more chirped fibre gratings in a particular optical path are reflected by a respective chirped fibre grating to whichever of the

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optical circulators is coupled via the switching elements
to the one or more chirped fibre gratings in that path.
Channels which are transmitted undisturbed through chirped
fibre gratings in an optical path are circulated to the
next optical path.   In this manner, all of the received
channels are circulated within the dispersion compensating
node until they reach a corresponding chirped fibre grating
and are reflected to the optical output or a drop port, as
determined by the switch states.

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Claims

1. A chromatic dispersion compensating node for connection to a transmission medium carrying a wavelength division multiplexed optical signal having N channels corresponding to N different wavelengths, comprising:

    (a)   an optical input;

    (b)   an optical output;

    (c)   at least one drop port; and,

    (d)   switching means for selectively coupling each of a series of N wavelength selective dispersion compensating elements, each of which is tuned to a respective one of the N wavelengths, to one of the drop port and the optical output, the node thereby selectively dropping one or more of the N channels and dispersion compensating all of the N channels.

2. A dispersion compensating node according to claim 1, comprising a first optical path and a second optical path, wherein the switching means are arranged selectively to switch a number of the wavelength selective dispersion compensating elements into the first optical path and selectively switch a number of the remaining wavelength selective dispersion compensating elements into the second optical path, so that signals reflected from dispersion compensating elements in the first optical path are coupled to one of the drop port and the optical output, one or more signals transmitted by the dispersion compensating elements in the first optical path are circulated within the node onto others of the dispersion compensating elements in the second optical path, and signals reflected from dispersion compensating elements in the second optical path are coupled to the other of the optical output and the drop port.

3. A dispersion compensating node according to claim 1 or claim 2, comprising a plurality of drop ports.

4. A dispersion compensating node according to any preceding claim, further comprising an insert port.

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5. A dispersion compensating node according to any preceding claim, in which the wavelength selective compensating elements are chirped fibre gratings.

6. A dispersion compensating node according to any preceding claim, in which the optical input and optical output are optical circulators.

7. A dispersion compensating node according to any preceding claim, in which the switching means are a number of discrete 2x2 non-blocking optical switches.

8. A dispersion compensating node according to any of claims 1 to 6, in which the switching means comprises an MxN multi-point switch.

9. A dispersion compensating node according to any preceding claim, comprising a concatenated series of N wavelength selective dispersion compensating elements and switching means.

10. An optical communication network comprising a number of chromatic dispersion compensating nodes in accordance with any preceding claim.

11. An optical communication network according to claim 10, further comprising a network node controller for controlling the switch state of each of the switching elements.

12. A cross-point switch for an optical network comprising two chromatic dispersion compensating nodes according to any of claims 1 to 9, in which a drop port of each node is connected to an optical path of the other node.

13. A cross-point switch according to claim 12, in which a drop port of one node is connected to an insert port of the other node.

14. A cross-point switch according to claim 12 or 13, in which the switch states of the switching means in the two connected nodes are dependent upon each other.

15. A cross-point switch according to claim 12 or 13, in which the switch states of the switching means are independent of each other.

15

16. A cross-point switch according to claim 15, in which the drop ports include optical circulators to provide a local drop facility.

17. An optical communication network comprising a number of cross point switches in accordance with any of claims 12 to 16.

18. An optical communication network comprising a combination of one or more chromatic dispersion compensating nodes according to any of claims 1 to 9 and one or more cross-point switches according to any of claims 12 to 16.

19. A method of dispersion compensating an optical signal having N channels corresponding to N different wavelengths, comprising the steps of:

(a) selectively coupling each of a series of N wavelength selective dispersion compensating elements, each of which is tuned to a respective one of the N wavelengths, to one of a drop port and an optical output; and,

(b) introducing the optical signal to an optical input, thereby selectively dropping one of more of the N channels and dispersion compensating all of the N channels.

20. A method according to claim 19, further comprising the steps of:

(c) selectively switching a number of the wavelength selective dispersion compensating elements into a first optical path; and,

(d) selectively switching a number of the remaining wavelength selective dispersion compensating elements into a second optical path,

wherein signals reflected from dispersion compensating elements in the first optical path are coupled to one of the drop port and the optical output, one or more signals transmitted by the dispersion compensating elements in the first optical path are circulated onto others of the dispersion compensating elements in the second optical path, and signals reflected from dispersion compensating

elements in the second optical path are coupled to the other of the optical output and the drop port.
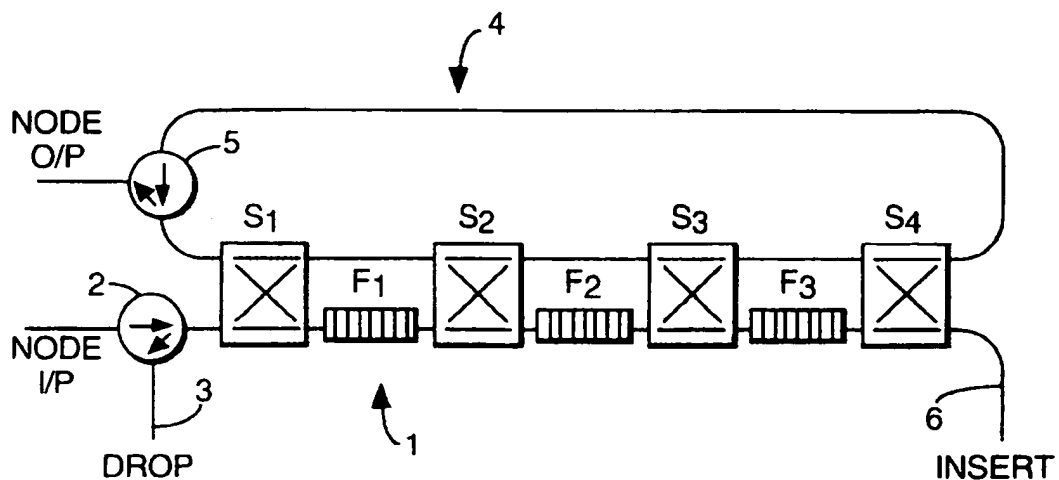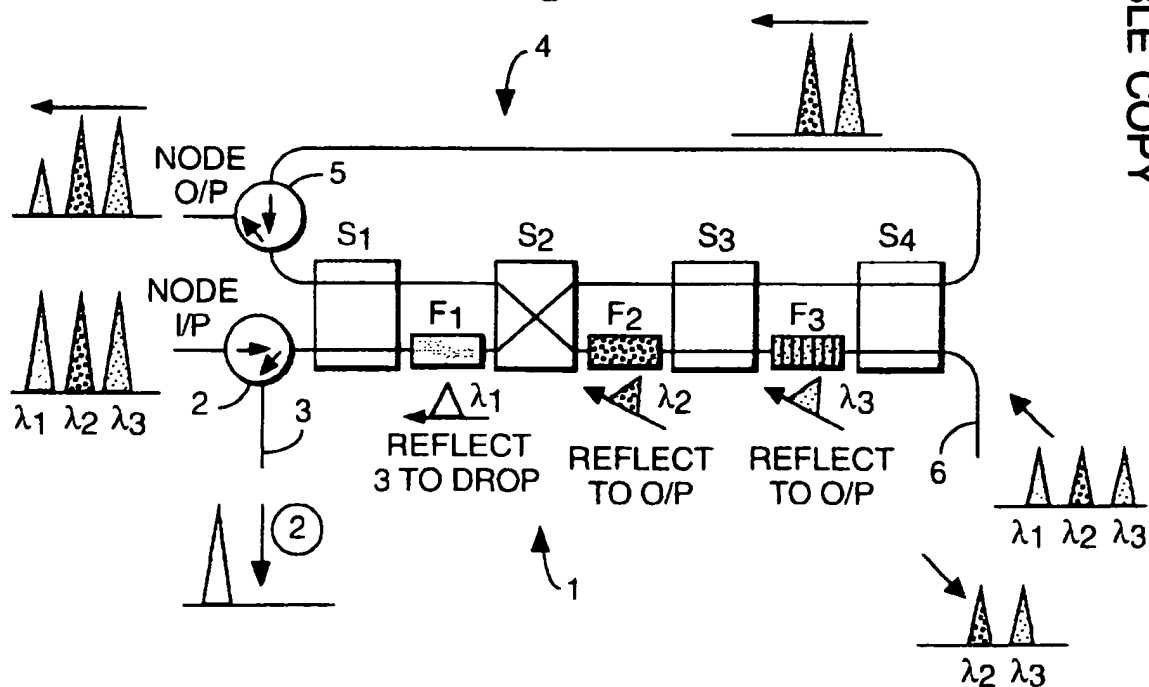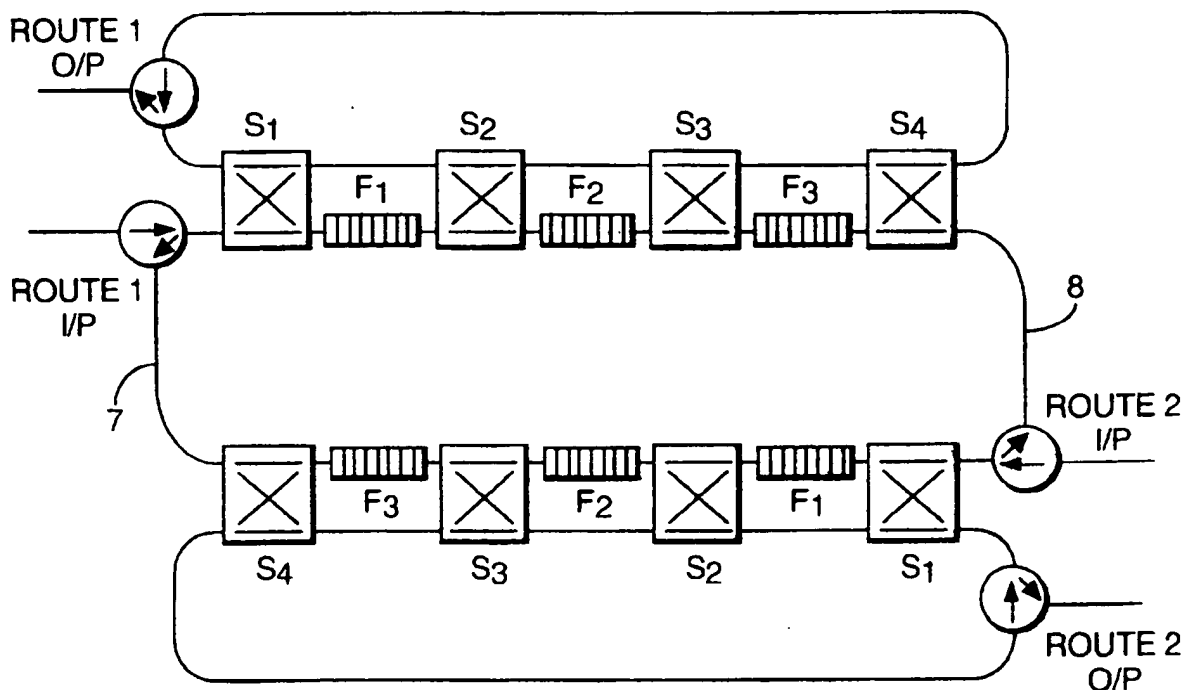
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Fig.1.

Fig.2.

Fig.3.

Fig.4.

Fig.5.

NETWORK MANAGEMENT CONTROLLER   12

λ_0 (λ_1) (λ_2) (λ_3) 13

LOGIC ARRAY

14

16

S_1 S_2 S_3

DISPERSION COMPENSATING NODE

15

(λ_1, λ_2)

17

DROP

18

INSERT
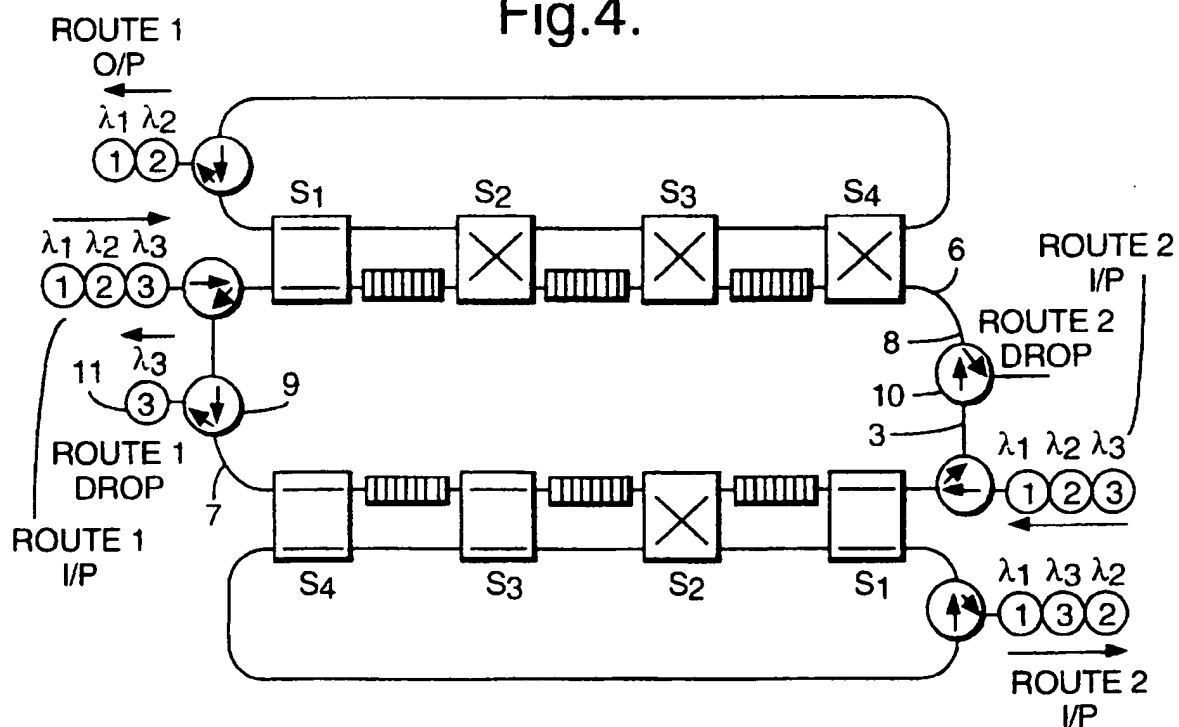
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Fig.6.

Fig.7.

Fig.8.

DROP 23

I/P 22

O/P 25

1 2 3 4 5 6 7

1 2 3 4 5 6 7

20

F3

INSERT 26

19

Fig.9.

DROP 23

I/P 22

O/P 25

1 2 3 4 5 6 7

1 2 3 4 5 6 7

20

F1

F2

F3

F4

INSERT 26

19
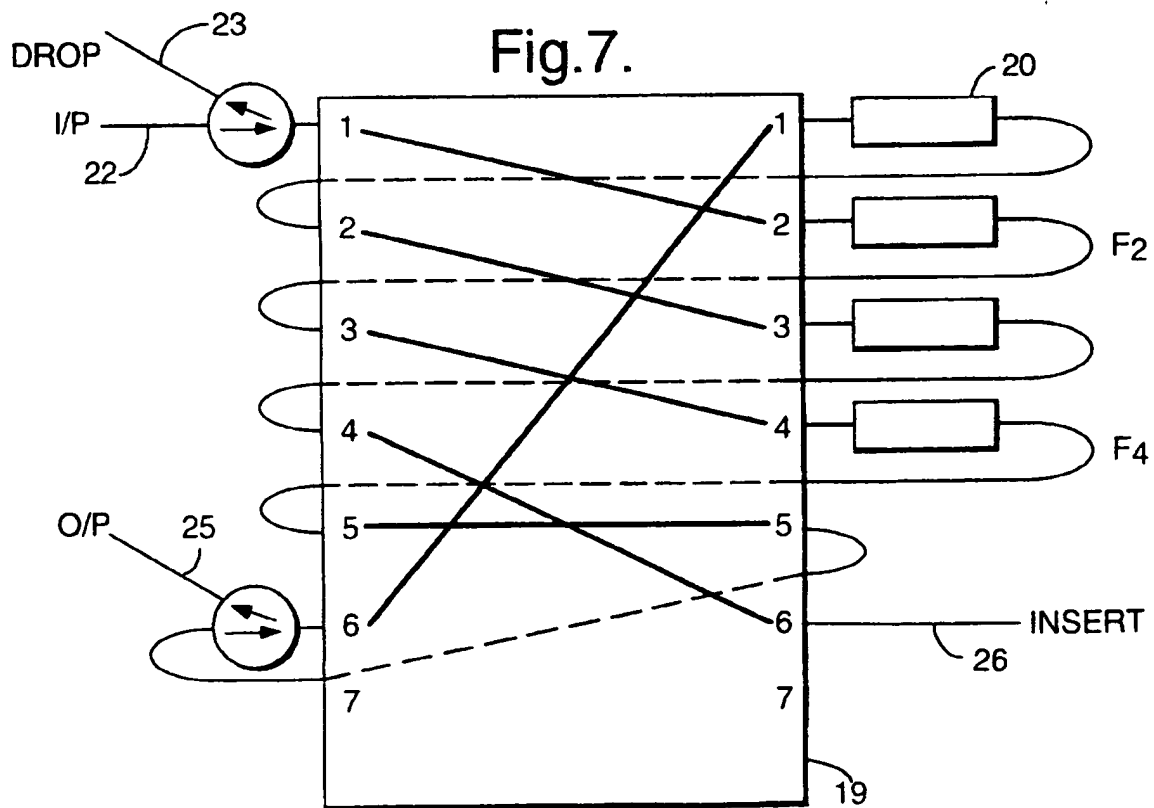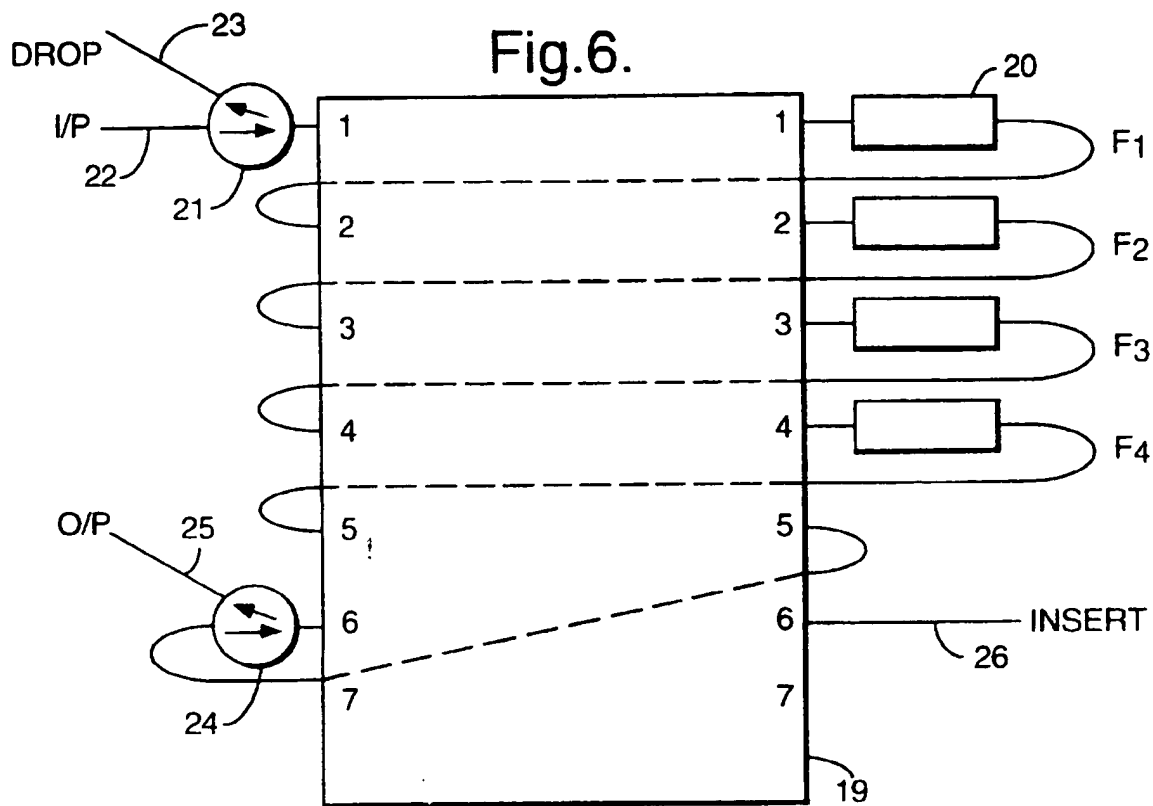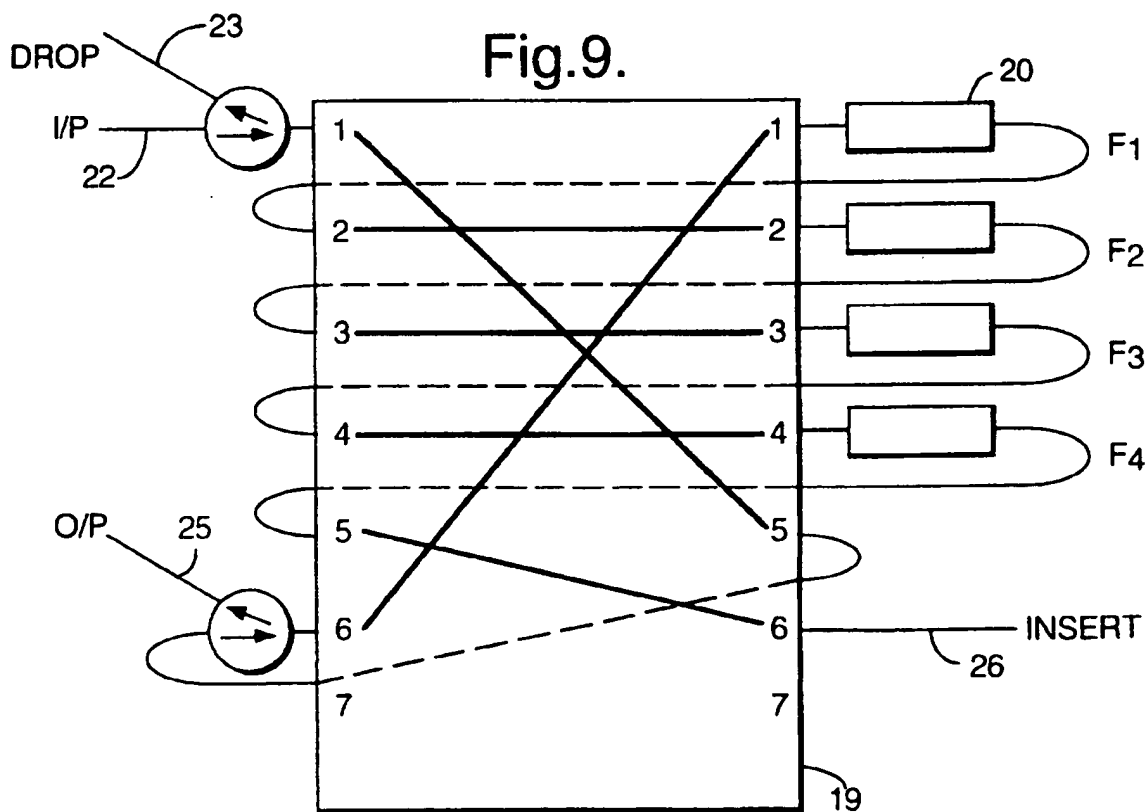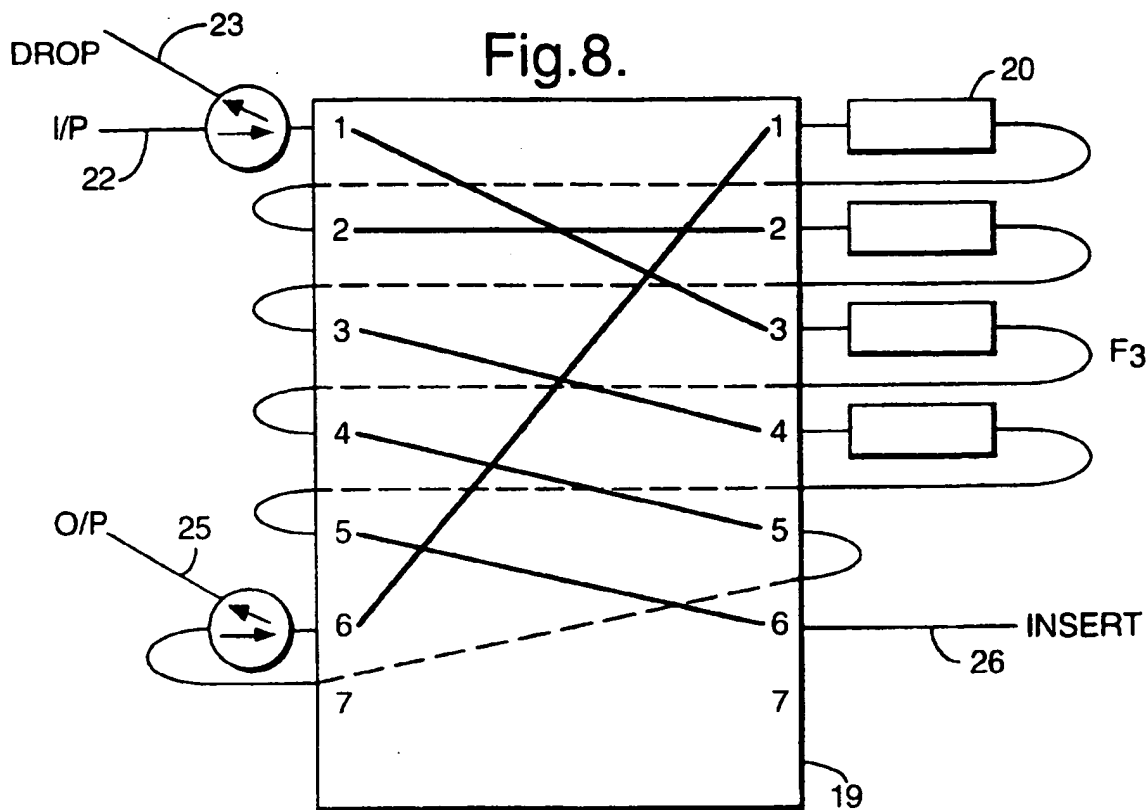
Fig.10.
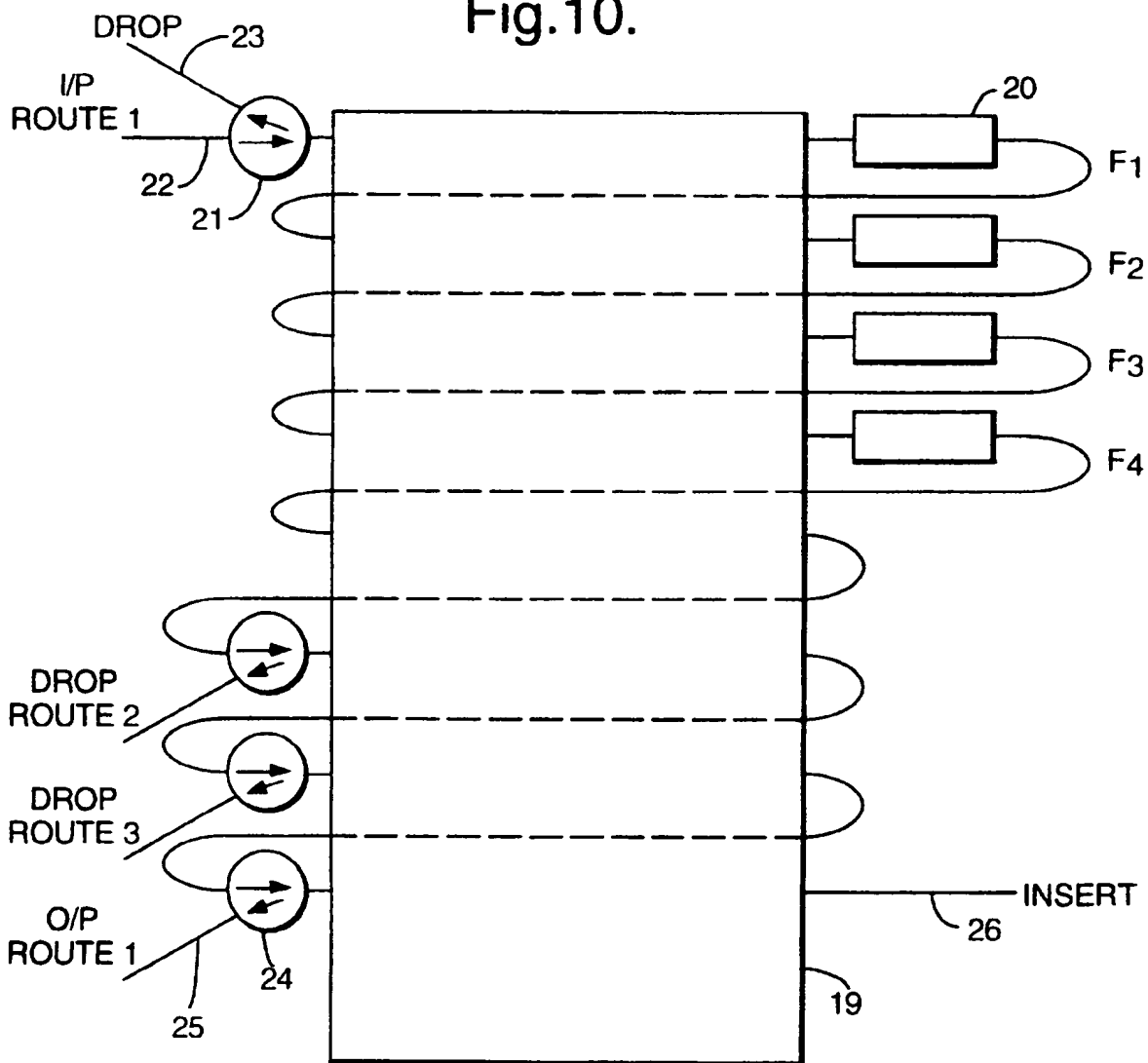
Fig.11.
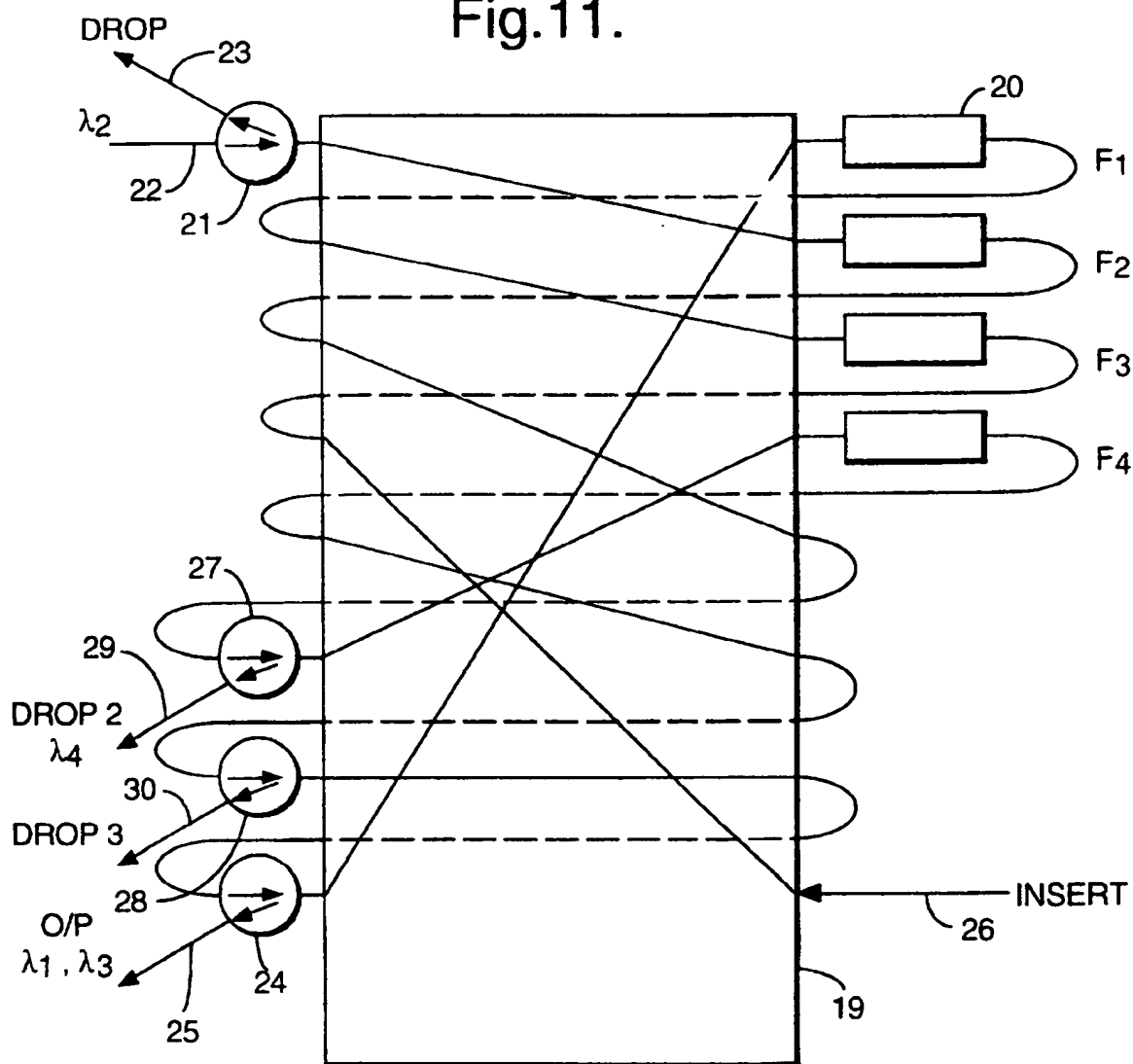
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6   H04B10/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6   H04B   G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 048 909 A (HENRY CHARLES H ET AL) 17 September 1991 cited in the application	1,5,10, 19
A	see abstract; figures 1,6,7	2,3,7,9, 20
	see column 2, line 28 - line 53 see column 6, line 56 - line 59 ---	
A	EP 0 591 042 A (NIPPON TELEGRAPH & TELEPHONE) 6 April 1994 see abstract; figures 1,17-21 ---	1,7-10, 19
	-/--	

| X | Further documents are listed in the continuation of box C. | | X | Patent family members are listed in annex. |

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Date of the actual completion of the international search	Date of mailing of the international search report
3 June 1997	23.06.97

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European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Goudelis, M

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ELECTRONICS LETTERS, vol. 31, no. 11, 25 May 1995, pages 899-901, XP000519114 OUELLETTE F ET AL: "BROADBAND AND WDM DISPERSION COMPENSATION USING CHIRPED SAMPLED FIBRE BRAGG GRATINGS" see abstract -----	1,5,19

2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US 5048909 A	17-09-91	DE	69116458 D	29-02-96
		DE	69116458 T	08-08-96
		EP	0468715 A	29-01-92
		HK	145196 A	09-08-96
		JP	4242227 A	28-08-92
		US	RE35516 E	20-05-97
		US	5093876 A	03-03-92
EP 0591042 A	06-04-94	CA	2107181 A	30-03-94
		JP	7098424 A	11-04-95
		US	5414548 A	09-05-95